UNIVERSITY OF BURGUNDY

MASTERS IN COMPUTER VISION AND ROBOTICS

A Gaussian Mean Shift Clustering based Segmentation of HR Satellite Imagery

*A Research Paper Analysis under the guidance of **Prof.Laligant Olivier***

WORKING TEAM

FRANCOIS LEGRAND

VAMSHI KODIPAKA

OLIVIER AGBOHOUI

Overview

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- Proposed Level Set Approach
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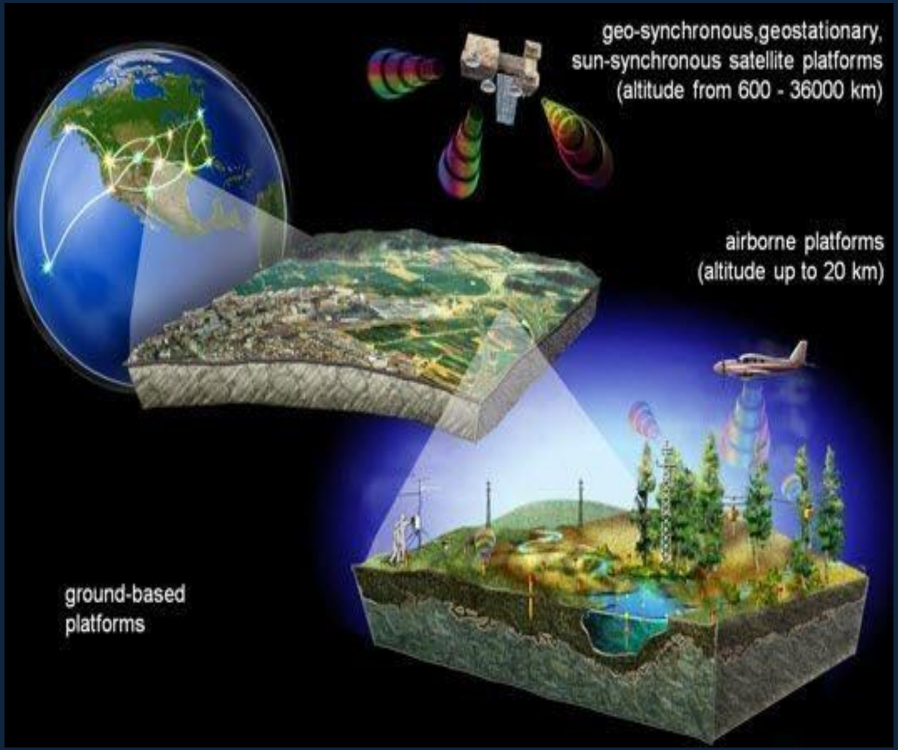


INTRODUCTION

Satellite Imagery:

High resolution imaging system able to make ground acquisition by collecting multispectral images

<ins>**Example:**</ins>

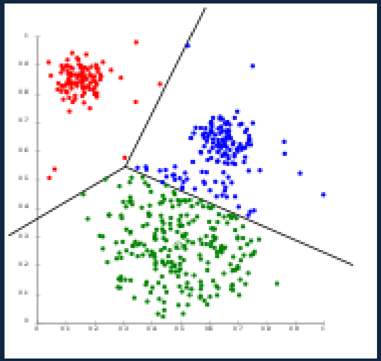
GeoEye-1 **satellite** has resolution of 0.41 meters (16 inches) in the panchromatic or black and white mode.

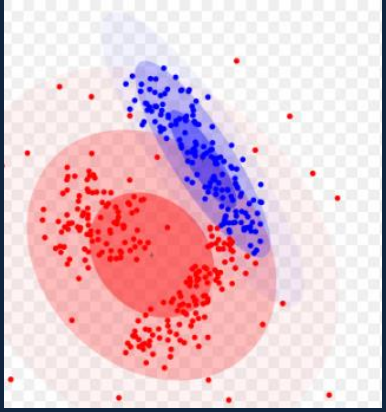
AIM:

A Mean Shift Clustering Based Segmentation of HR Satellite Imagery with Level set Approach

SEGMENTATION

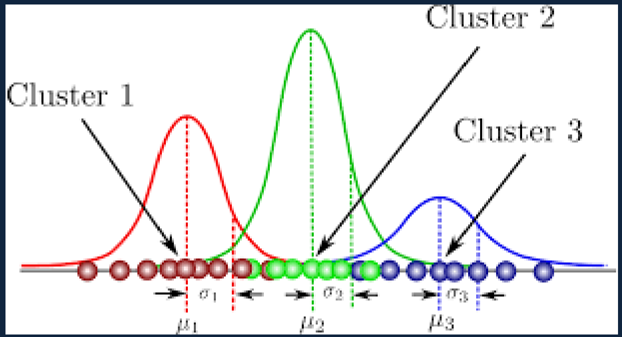
- process of partitioning a digital image into multiple segments.
- It subdivides an image into it's regions or objects.
- more meaningful and easier to analyze.
- object of interest in an application has to be isolated.





Two main categories::

1. edge-based
2. region-based.



GAUSSIAN MEAN SHIFT

Mean shift considers feature space as a empirical probability density function

- Kernel density estimator function :

$$f(x) = \frac{1}{nh^d}\sum_{i=1}^{n} K\left(\frac{x-x_i}{h}\right)$$

- Mean shift density

$$\nabla f(x) = \frac{2c_k}{nh^{(d+2)}}\sum_{i=1}^{n}(x-x_i)\,k'\left(\left\|\frac{x-x_i}{h}\right\|^2\right)$$

At density maxima $\nabla f(x) = 0$

With :

$$g_i = g\left(\left\|(x-x_i)/h\right\|^2\right)$$

$$\frac{2c_k}{nh^{(d+2)}}\left(\sum_{i=1}^{n} g_i\right)\left(\frac{\sum_{i=1}^{n} x_i g_i}{\sum_{i=1}^{n} g_i} - x\right)$$

Mean shift defines a window around it and computes the mean of the data point. Then it shifts the center of the window to the mean and repeats the algorithm till it converges.

GAUSSIAN MEAN SHIFT

- Mean shift vector :

$$m(x)=\frac{\sum_{i=1}^{n} x_i g_i}{\sum_{i=1}^{n} g_i}-x$$

- Successives locations of the Kernel :

$$y_{j+1}=\frac{\sum_{i=1}^{n} x_i g\left(\left\|\frac{y_j-x_i}{h}\right\|^2\right)}{\sum_{i=1}^{n} g\left(\left\|\frac{y_j-x_i}{h}\right\|^2\right)}$$

- General structure :

1. h=0.2
2. j=1
3. while j < N
4. $$y_2=\frac{\sum_{i=1}^{n}\frac{1}{h^{d+2}}x_i g\left(\left\|\frac{y_j-x_i}{h}\right\|^2\right)}{\sum_{i=1}^{n}\frac{1}{h^{d+2}} g\left(\left\|\frac{y_j-x_i}{h}\right\|^2\right)}$$
5. $y_1 = y_2$
6. j =j+1
7. End while

CHAN-VESE ACTIVE CONTOUR (GAC)

- Chan-Vese model formulation : $E^{cv} = \lambda_1 \int\limits_{inside(c)} |I(x) - C_1|^2 dx + \lambda_2 \int\limits_{outside(c)} |I(x) - C_2|^2 dx, x \in \Omega$

- The Chan-Vese formulation uses the following constants C1 and C2 :

$$C_1 = \frac{\int_\Omega I(x).H(\phi)dx}{\int_\Omega H(\phi)dx}$$

$$C_2 = \frac{\int_\Omega I(x).(1 - H(\phi))dx}{\int_\Omega (1 - H(\phi))dx}$$

- By adding length and area energy terms to the Kernel density estimator, one reach :

$$\frac{\partial\phi}{\partial t} = \partial(\phi)\left[\mu\nabla\left(\frac{\nabla\phi}{|\nabla\phi|} - \nu - \lambda_1(I - C_1)^2 + \lambda_2(I - C_2)^2\right)\right]$$

SPF FUNCTION DESIGN

H(φ) Is the Heaviside function and δ(φ) is the Dirac function. Generally, the regularized versions are selected as follows:

$$H_\varepsilon(z) = \frac{1}{2}\left(1 + \frac{2}{\pi}\arctan\left(\frac{z}{\varepsilon}\right)\right),$$

$$\delta_\varepsilon(z) = \frac{1}{\pi}\cdot\frac{\varepsilon}{\varepsilon^2 + z^2}, Z \varepsilon R$$

signs of the pressure force (SPF):

inside and outside the region of interest so that the contour shrinks when outside the object, or expands when inside the object

$$spf(I(x)) = \frac{I(x) - \frac{c_1 + c_2}{2}}{\max\left(\left|I(x) - \frac{c_1 + c_2}{2}\right|\right)}, x \varepsilon R$$

$$\min(I(x)) \leq \frac{c_1 + c_2}{2} \leq \max(I(x)), x \varepsilon \Omega$$

GAC model, the level set formulation of the proposed model :

$$\frac{\partial \phi}{\partial t} = spf(I(x)).\left(div\left(\frac{\nabla \phi}{|\nabla \phi|}\right) + \alpha\right)|\nabla \phi| + \nabla spf(I(x)).\nabla \phi, x \varepsilon R$$

PROPOSED LEVEL SET APPROACH

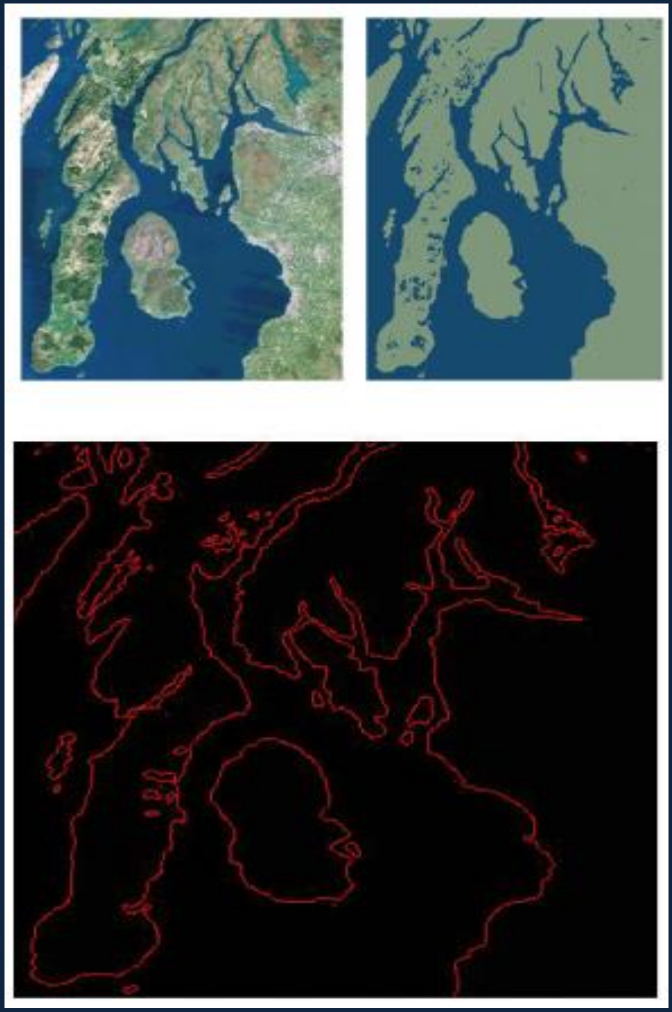
the level set formulation of the proposed model

$$\frac{\partial \phi}{\partial t} = spf(I(x)).\alpha \left| \nabla \phi \right|, x\varepsilon\Omega$$

proposed algorithm are summarized as follows:Initialize the level set function Φ :

$$\phi(x, t=0) = \begin{cases} -\rho & x\varepsilon\Omega_0 - \delta\Omega_0 \\ 0 & x\varepsilon\delta\Omega_0 \\ \rho & x\varepsilon\Omega - \Omega_0 \end{cases}$$

Regularize the level set function with a Gaussian filter, i.e. **ϕ = ϕ *Gσ**



ADVANTAGES

- Much more reactive to edges
- Simple approach : binarization based then Gaussian regularization
- Region based SPF instead of edge based
- When clustering small windows, noise can be excluded
- More precision for less operation time
- Quick application to real time imaging

References

Presented papers :

K. Ramudu, “A Mean Shift Clustering Based Segmentation of HR Satellite Imagery using Level set Approach”

K. Ramudu, “Global Region Based Segmentation of Satellite and Medical Imagery with Active Contours and Level Set Evolution on Noisy Images”

More information :

D. Mumford, J. Shah, “Optimal approximation by piecewise smooth function and associated variational problems”

L.A. Vese, T.F. Chan, “A multiphase level set framework for image segmentation using the Mumford–Shah model”

Thank you...